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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
H04M 1/19, H04R 3/00, G10L 3/02

A1

(11) International Publication Number: **WO 99/11045**

(43) International Publication Date: 4 March 1999 (04.03.99)

(21) International Application Number: PCT/GB98/02518

(22) International Filing Date: 21 August 1998 (21.08.98)

(30) Priority Data:
9717816.4 21 August 1997 (21.08.97) GB

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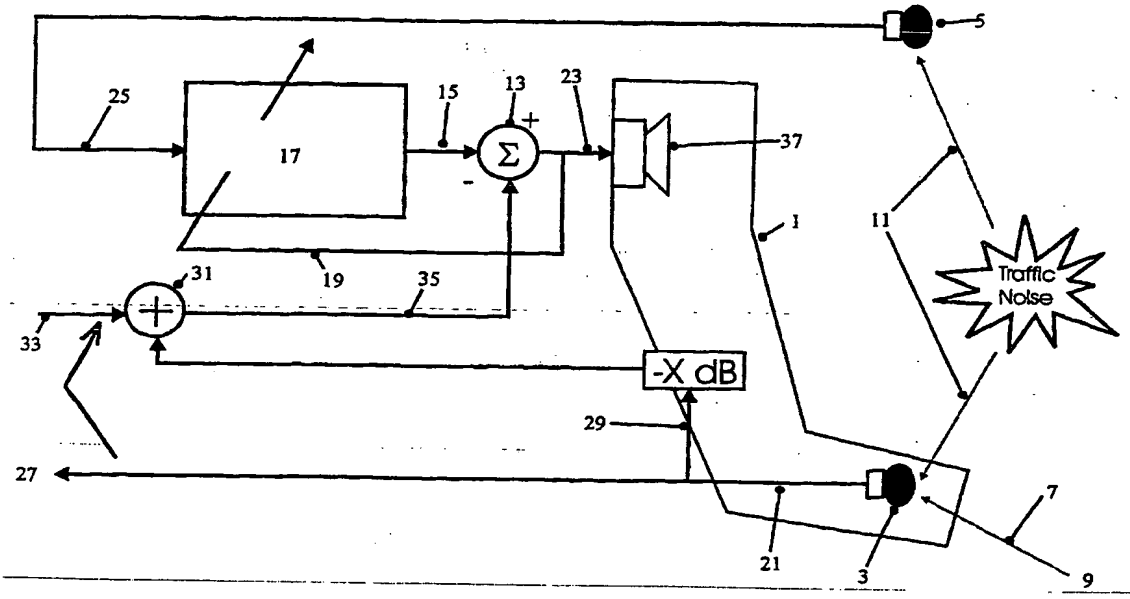
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: TELEPHONE HANDSET NOISE SUPPRESSION



(57) Abstract

In order to improve the use of a telephone handset (1), there is provided a method of attenuating the noise generated in the environment by deriving an anti–noise signal (15) from a reference microphone (5) and combining this signal with instrument sidetone (35) for supply to the earpiece (37) of the handset (1). The anti–noise signal (15) may be mixed with the handset microphone signal or voice signal (7) before onward transmission of this signal to the telephone network. As a result the improvements in intelligibility are available not only to the handset user but also the receiving party.

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Telephone Handset noise suppression

The present invention relates to noise suppression for a telephone handset, particularly, although not exclusively a handset forming part of a roadside emergency telephone.

It is well known that when a telephone handset is used in a noisy environment, such as that found by the roadside, its performance suffers both in terms of the intelligibility of the speech signal emitted from the earpiece of the handset and the quality of the signal conveyed from the mouthpiece of the handset to a remote party. There have been proposals to improve the performance of such a handset, for the most part centred on the use of active noise control techniques for which the theory is well known to those skilled in the art. Previously, such techniques have been limited in their utility because of the high cost of signal processing hardware such as, for example, Digital Signal Processors (DSP). However, more recently, the technology has become affordable particularly when applied to mass-production items such as telephone handsets.

Thus, it is an object of the present invention to provide an improved telephone handset employing a novel adaptive noise suppression technique. It is a further object of the invention to utilise the above adaptive technique in conjunction with adaptive noise cancellation methods.

According to the present invention, there is provided a method of improving intelligibility of telephone-handset communication in a noisy environment including the steps of:

adaptively filtering a noise signal obtained from a reference microphone to derive an anti-noise signal and

combining this signal with a sidetone signal derived from a mouthpiece microphone such that the noise signal present in the sidetone signal is substantially removed leaving a signal with the noise attenuated for supply to an earpiece as instrument sidetone.

According to a further aspect of the invention, there is provided apparatus suitable for carrying out the above described method.

It will be immediately apparent that although the anti-noise signal may be mixed with the sidetone signal after the latter signal has been split from the mouthpiece microphone signal carrying voice and noise signals to the telephone network, the removal of noise may take place prior to splitting the microphone signal thereby resulting in a substantially noise-free voice signal reaching not only the earpiece but also the telephone network. This has the effect of further reducing the noise received at the earpiece by reflections of the signal sent to the telephone network.

Additionally, and to further improve the operation of the handset, means may be provided for forming a so-called zone-of-quiet around the earpiece of the handset. Such means may also have the ability to compensate for changes in the acoustic path caused by different handset characteristics and/or the force with which the handset is applied to an ear of a caller.

In order to aid in understanding the invention a specific embodiment thereof will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram setting out the principal of adaptive noise cancellation;

Figure 2 is a schematic diagram of a telephone handset and filter apparatus according to the invention to allow noise suppression of a sidetone signal;

Figure 3 is a schematic diagram of a variant of the telephone handset of Figure 2;

Figure 4 is a schematic diagram of the telephone handset of Figures 3 and 4 further incorporating earpiece adaptive noise cancellation apparatus; and

Figure 5 is a schematic diagram of the handset of Figure 4 showing the adaptive noise cancellation circuitry in more detail.

Referring initially to Figure 1, this describes the principal of operation of an adaptive filter apparatus for use with a roadside emergency telephone handset 1. In the following description, the conventional telephony term for the party using the handset, namely the "caller", is referred to as the "user". Similarly, the word "operator" used below corresponds to the conventional term of "receiving party".

The apparatus 1 has a pair of microphones 3,5 of which one microphone 3 is arranged to receive a voice signal s(k) 7 from a user 9 calling for assistance and which, in addition, unavoidably receives unwanted background traffic noise n(k) 11. A second microphone 5 which is substantially acoustically isolated from the user 7 is arranged to deliberately receive traffic noise n'(k) 11 only. The combined signal s(k) 7 and noise n(k) 11 are summed in summing means 13 with the output y(k) 15 from an adaptive filter 17. The output y(k) 15 from the filter 17 is, itself, the result of applying a known filter algorithm to the noise n'(k) 11 received by the second microphone, in accordance with the feedback of the output e(k) 19 from the summing means 13. The output e(k) 19 is, of course, intended to correspond as closely as possible to the voice

signal s(k) 7 of the user and is subsequently received by an operator listening to the user's requests for assistance.

Figures 2 and 3 show an adaptive filter apparatus employed in a telephone handset to reduce the detrimental effect of traffic noise being fed to the user's ear via instrument sidetone. Sidetone, which is low-volume feedback of the user's voice signal to the earpiece of the instrument, is a requirement of telephone operating authorities and provides reassurance to the user that the handset is not "dead".

Referring to Figure 2 especially, traffic noise 11 is received by reference microphone 5 and handset microphone 3. In addition, a voice signal 7 is received at the handset microphone 3 from the user 9. The output signal 21 from the handset microphone 3 is passed principally, via the telephone network to an operator 27. However, a portion of the output signal 21 is spilt away as sidetone 29. This sidetone signal 29 is mixed in mixer means 31 with an incoming operator voice signal 33. The combined operator signal and sidetone 35 is then passed to the summing means 13 where it is summed with the output 15 of the adaptive filter 17. Consequently, the output from the summing means 13 namely output signal 23 contains merely the instrument sidetone signal and the voice signal 33 of the operator 27, the unwanted traffic noise 11 being substantially removed. This signal 23 is then used to drive the earpiece 37 of the handset 1.

Turning to Figure 3, there is shown a variation of the handset in which the adaptive filter apparatus of Figure 1 is employed not only to remove unwanted traffic noise 11 from the sidetone 29 fed to the user 9, but also reduces the unwanted traffic noise 11 passed to the operator 27.

In this arrangement, voice signal 7 and traffic noise 11 are received by the handset microphone 3 and reference microphone 5 and adaptively filtered as described above. In the present case however, a substantially noise free signal 23 is obtained which can be fed to the operator and a portion thereof fed, as noise-free sidetone for subsequent mixing with the operator voice signal 33. In this way, the benefit of adaptive filtering is available both to the user 9 and the operator 27.

It will be appreciated by those skilled in the art that the adaptive noise cancellation techniques may be employed to produce a so-called zone-of-quiet around the earpiece of the handset as shown in Figure 4 and in more detail in Figure 5.

Referring to Figure 5, traffic noise 11 is received by reference microphone 5 and handset microphone 3. In addition, a voice signal 7 is received at the handset microphone 3 from the user 9, enabling an instrument sidetone level to be derived via an attenuator. The user 9 receives an audible signal 40 from the earpiece 37 via an acoustic path 43 having an impulse response He(f). Reference microphone 5 is substantially acoustically isolated from microphone 3 and error microphone 38. Traffic noise 11 received by reference microphone 5 produces a noise signal x(k) 25 which is fed to adaptive filter 46, model of impulse response He(f), $\hat{He}(z)$ 42, and sidetone control element 41. Adaptive filter 17 uses noise signal x(k) 25, coefficients from the model of impulse response $\hat{He}(z)$ 42 and an error signal 44, produced by an error microphone 38 situated within the acoustic path He(f) 43, to produce an anti-noise signal 45. The anti-noise signal 45 is fed to a mixer means 31 to be combined with the signal received from the telephone network 33 and the instrument sidetone signal via the sidetone control element

41. The resulting signal from the mixer 31 output y(k) 35 is fed to earpiece 37. The adaptive filter 17 operates so as to produce an acoustic sound from earpiece 37, picked up by error microphone 38, which acoustically cancels the traffic noise 11 whilst preserving the signal received from the telephone network 33 and instrument sidetone via sidetone control element 41.

In order to compensate for changes in acoustic path He(f), caused for example by different characteristics of individual handsets or the force applied by the user to hold the handset to their ear, the coefficients held within the acoustic path model $\hat{He}(z)$ 42 are dynamically updated. As the level of traffic noise signal 25 increases the sidetone control element 41 reduces the amount of instrument sidetone during periods of high traffic noise.

It will be appreciated that the control of instrument sidetone by means of a sidetone control element 41 in response to the level of noise signal 25 may be applied to a telephone instrument not equipped with either adaptive noise cancellation or adaptive noise control.

Claims:

1. A method of improving intelligibility of telephone-handset communication in a noisy environment including the steps of:

adaptively filtering a noise signal obtained from a reference microphone to derive an anti-noise signal and combining this signal with a sidetone signal derived from a mouthpiece microphone such that the noise signal present in the sidetone signal is substantially removed leaving a signal with the noise attenuated for supply to an earpiece as instrument sidetone.

2. A method as claimed in Claim 1, wherein the reference microphone is firstly isolated acoustically from the handset, the noise signal then being adaptively filtered in accordance with a predetermined model of the handset impulse response as modified by the value of an error signal obtained from a error microphone situated within the acoustic path of the handset earpiece and thereby derive the anti-noise signal.

3. A method as claimed in Claim 2, wherein the model of handset impulse response is dynamically updated in accordance with the pressure applied to the handset by a users head.

4. A method as claimed in any preceding Claim, wherein the anti-noise signal is mixed with the sidetone signal after the latter signal has been split from the mouthpiece microphone signal which provides a caller signal to the telephone network.

5. A method as claimed in any one of Claims 1 to 3, wherein the anti-noise signal is mixed with the mouthpiece

microphone signal prior to splitting the microphone signal into a sidetone signal and a caller signal sent to the telephone network.

6. A method as claimed in Claim 4 or Claim 5, which includes the further step of summing a receiving party signal received from the telephone network with the sidetone signal.

7. A method as claimed in any preceding Claim, wherein the sidetone signal varies inversely with relation to the level of the noise signal.

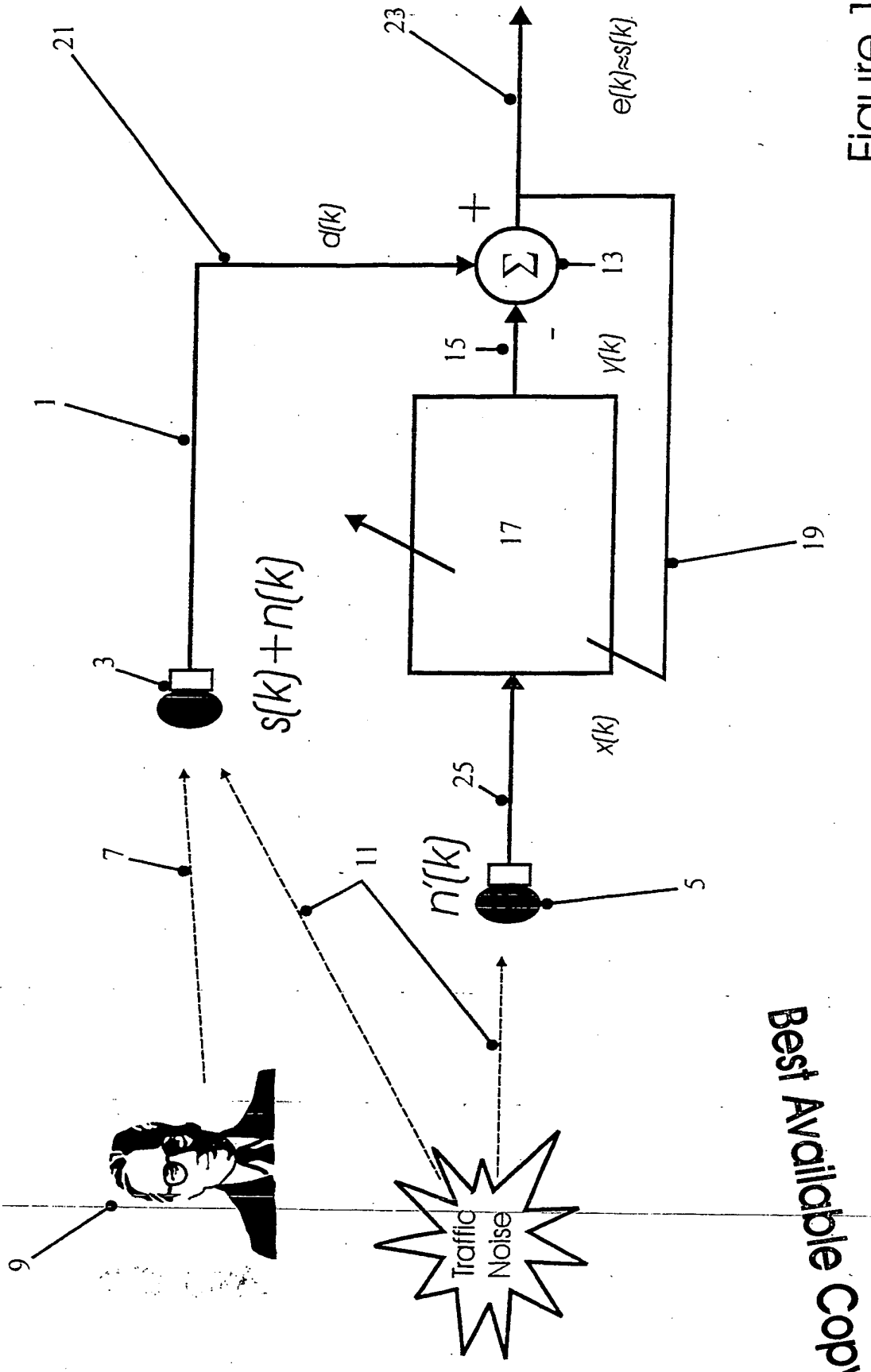

Figure 1

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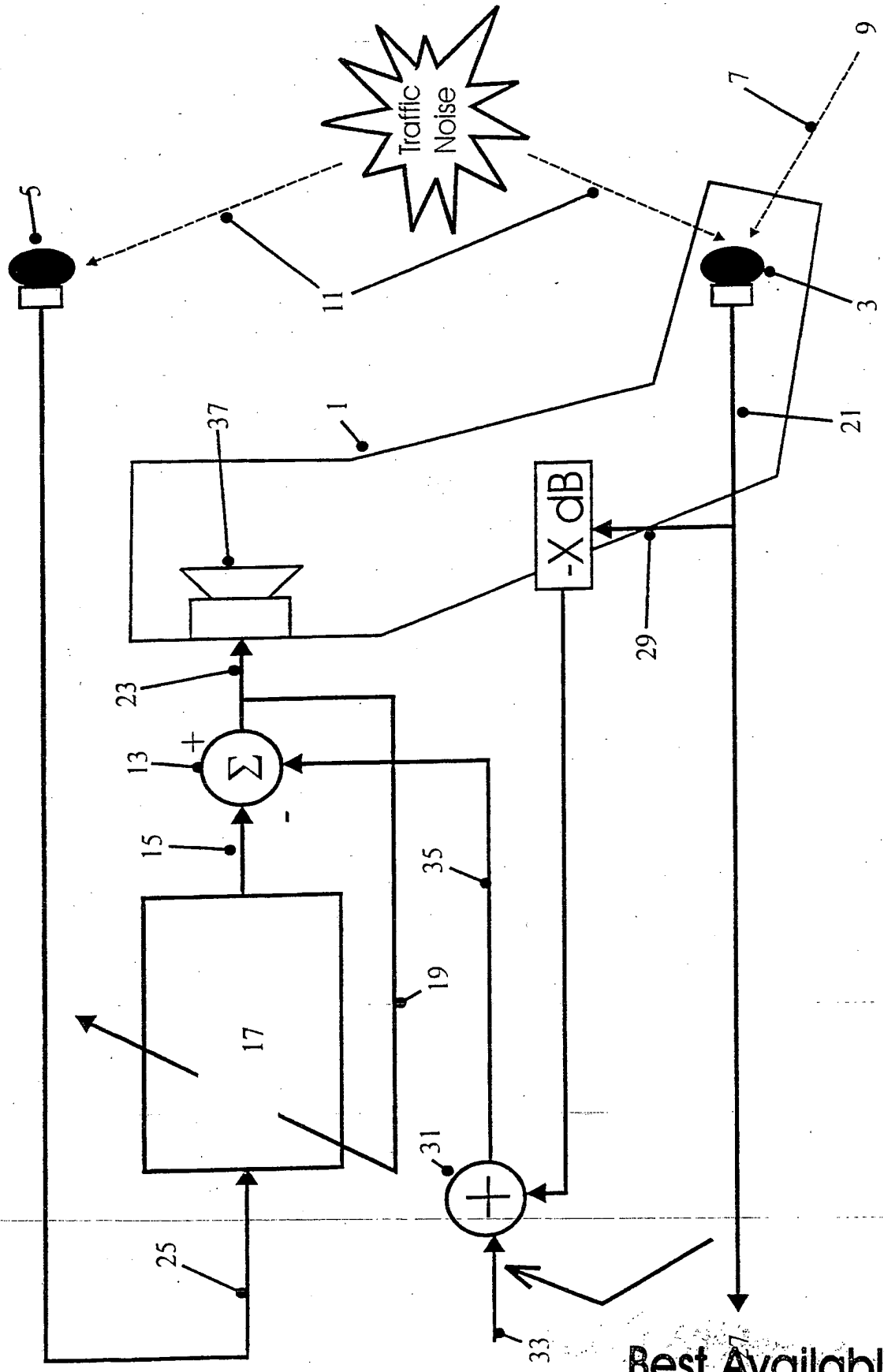

Figure 2

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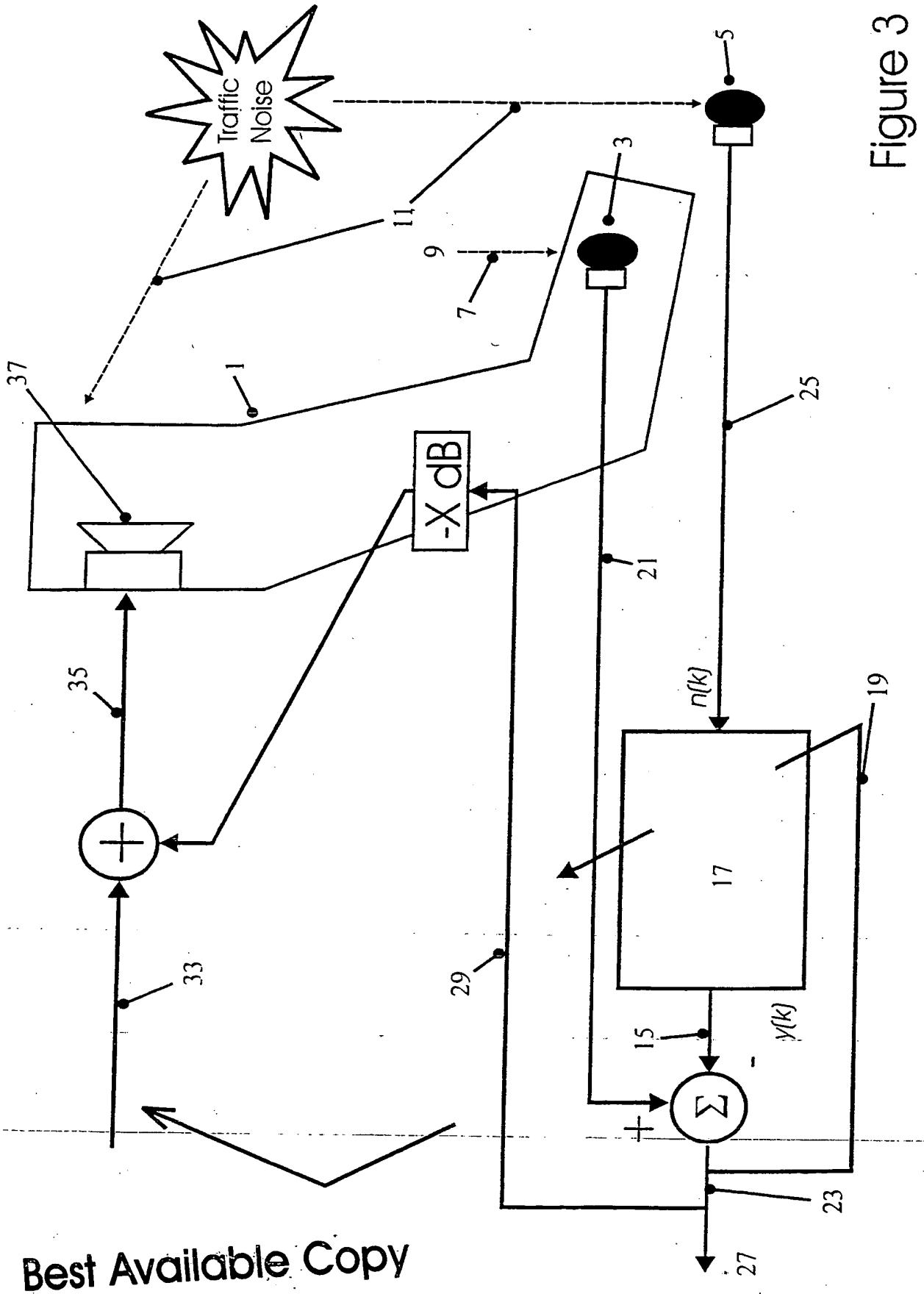

Figure 3

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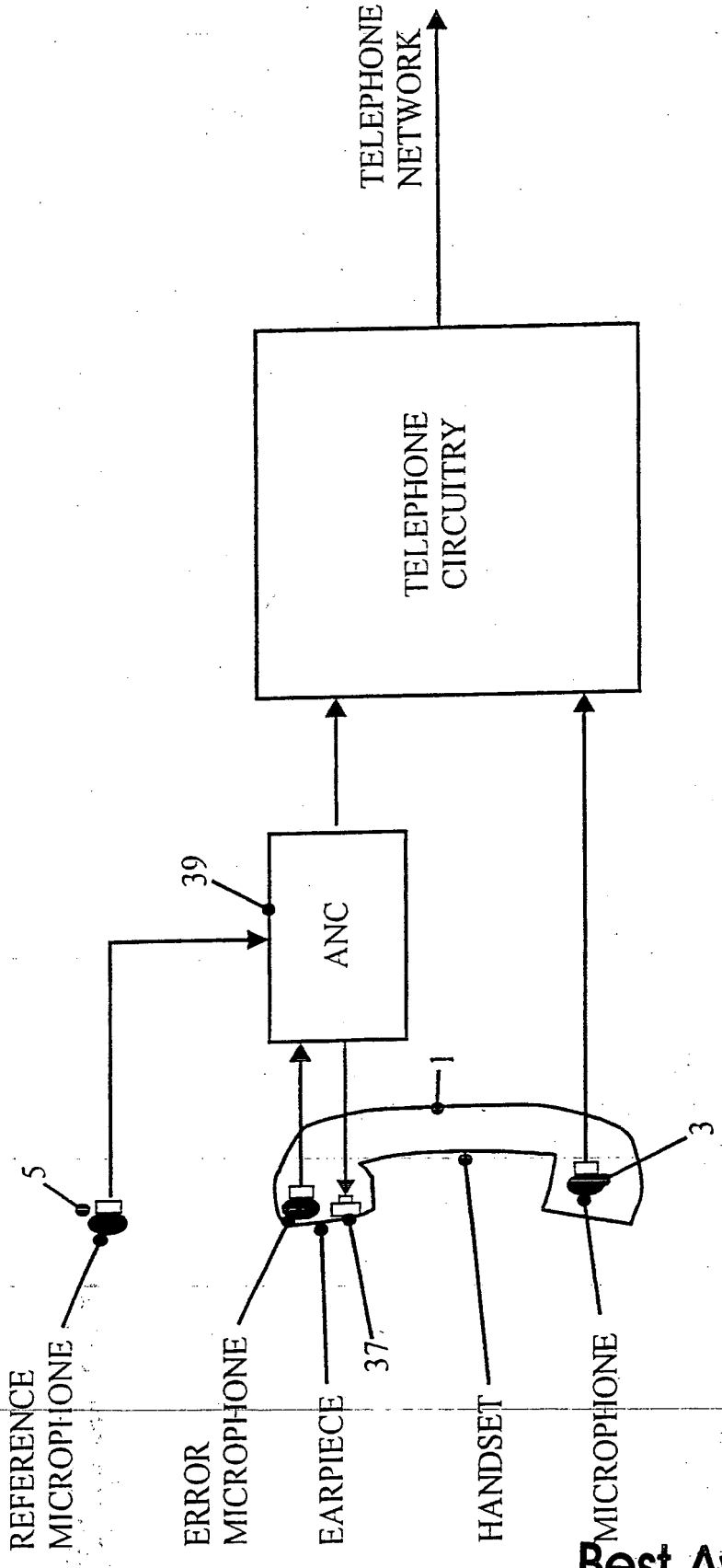

Figure 4

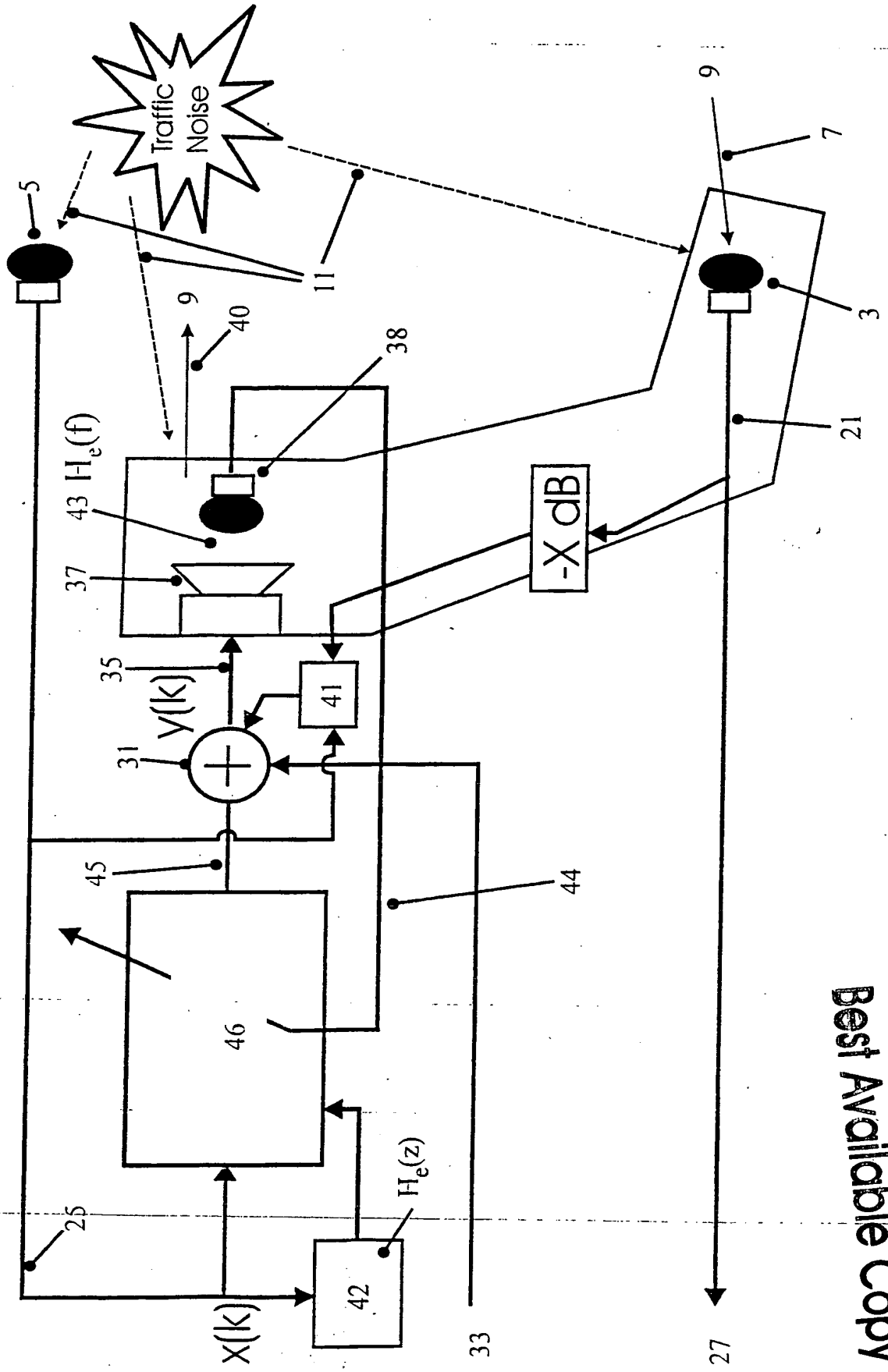

Figure 5

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 98/02518

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04M1/19 H04R3/00 G10L3/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 756 407 A (MATSUSHITA ELECTRIC IND CO LTD) 29 January 1997 see column 6, line 1 - column 7, line 49 see figures 1,2,7 ---	1-7
X	US 5 251 263 A (ANDREA DOUGLAS ET AL) 5 October 1993 see column 3, line 36 - column 4, line 29 see column 6, line 45 - line 61 see column 14, line 53 - column 15, line 11 see figures 1,4,9 ---	1-7
X	PATENT ABSTRACTS OF JAPAN vol. 017, no. 301 (E-1378), 10 June 1993 & JP 05 022391 A (SONY CORP), 29 January 1993 see abstract ---	1,5-7
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A	WO 92 05538 A (TODTER CHRIS ;CLIFTON SCOTT (AU); BREMNER PAUL (AU)) 2 April 1992 see page 29, line 9 - page 33, line 4 see figures 5-7,11	1,6
A	US 5 625 684 A (MATOUK ANTHONY F ET AL) 29 April 1997 see column 2, line 38 - column 5, line 11 see figures 2-4	1,6
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Information on patent family members

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